ACCELERATING SDG 7 ACHIEVEMENT

POLICY BRIEF 16

DIGITALIZATION AND THE FUTURE OF ENERGY SYSTEMS

POLICY BRIEF #16

DIGITALIZATION AND THE FUTURE OF ENERGY SYSTEMS

Developed by

The International Institute for Applied Systems Analysis (IIASA)

In collaboration with

The International Energy Agency (IEA)

Key Messages

Digitalisation offers huge potential to help deliver essential services (e.g., lighting, thermal comfort, communication needs, and mobility) in a more resource-efficient manner and support the achievement of the SDG 7 targets: providing electricity access to everyone (7.1), enabling higher shares of renewable energy (7.2), and supporting improvements in energy efficiency (7.3).

Today, digital technologies can be found in all energy demand and supply sectors, helping to improve the safety, productivity, accessibility and sustainability of energy systems worldwide.

On the energy supply side, the oil, gas, and electricity producers, as well as heavy industries, are using large IT systems to improve safety and productivity. Digital technologies are also influencing efficiency gains in the energy consumption, for example, through smart metering applications in buildings and car sharing systems. Meanwhile, transformative technologies such as autonomous cars are on the horizon in the transport sector, with potentially large but uncertain impacts on overall energy use. Digitalisation could also fundamentally transform the energy system by breaking down boundaries between energy sectors, increasing flexibility, and enabling integration across systems through: (1) smart demand response; (2) improved integration of variable renewable energy sources, (3) implementation of smart charging for electric vehicles (EVs); and (4) improved coordination of distributed electricity resources. Digital technologies and mobile networks can also unlock new business models to support rural electrification, providing electricity services to the 990 million people without electricity access today.

Appropriate policies are crucial to realising the full benefits of digitalisation and its role in achieving SDG 7, especially in terms of increased energy efficiency and integration of renewable energy into energy systems, while also managing potential risks around security, privacy, and rebound effects. With vast volumes of data being collected and processed, questions arise about which data will be critical and prioritised, who should own it, and how best to balance the risks and opportunities of data-driven solutions.

There is an urgent need to bring the sustainability and the digital/technology communities together to align the direction of social and economic change with the 2030 Agenda and a sustainable future, and implement forward-looking roadmaps and governance structures that allow the mitigation of potential trade-offs, particularly relating to impacts on the workplace, social cohesion, and human dignity.

To maximise the potential benefits that digitalisation can bring to the global energy system, policy makers need to build their own skills and knowledge of digital technologies, so that policy responses can be developed from a more informed position. Improved access to data will also open opportunities to realise the benefits from digitalisation, with governments well placed to develop frameworks and structures to access robust, verifiable and secure access to data, and to understand the impact that digitalisation is having on energy demand.

Overview

Digital technologies can support the transition to zero-carbon, circular and resilient societies. They are both indicators used for tracking the SDGs in themselves (e.g., Internet or mobile coverage) and enabling technologies to harness efficiency gains and inducing life style changes, for example in the energy system (e.g., smart metering, car sharing), related to environmental quality and health (e.g., water or air pollution monitoring).

Opportunities

A key element of a sustainability transformation is the notion that wellbeing does not necessarily rely on the consumption of resources per se but is rather derived from the services and amenities these resources help providing. Across a variety of resources (energy, water, land, materials) end-use demand is the ultimate driver and associated improvements in efficiency and reductions in waste therefore offer the largest leverage effects. The digital revolution offers huge potentials to make accessible these services in a much more resource efficient manner (Figure 1).

Figure 1. The rapid progress of information and telecommunication technologies could be an indication of the path-breaking potential of next-generation digital technologies and their clustering in new activities and associated behaviors. A smart phone needs between 2.2 Watts in standby to some 5 Watts in use, while the numerous devices portrayed in the figure that it replaces need up to hundred times more power. Bundling of services from various devices in the smart phone can be seen as an example for the power of the digital revolution and the huge potential of increasing the resource efficiencies through new technologies and behaviors. Graphic courtesy of Nuno Bento based on data in Grubler, Wilson et al. (2018) and visualization of Tupy (2012).

The energy sector has been an early adopter of large IT systems, notably in oil and gas, electricity, and heavy industry. Today, digital technologies can be found in all energy demand and supply sectors, helping to improve the safety, productivity, accessibility, and sustainability of energy systems worldwide. Rapid advances in data, analytics, and connectivity are accelerating the digitalization of energy, opening the door to new models of producing and consuming energy while also raising new security and privacy risks (IEA 2017).

Transport is becoming smarter and more connected, improving safety and efficiency. Digitalization could have its biggest impact on road transport, where connectivity and automation (alongside further electrification) could dramatically reshape mobility. The overall net impacts on energy use are highly uncertain, hinging on the interplay between technology, policy, and behaviour.

In buildings, digitalization could cut energy use by about 10 per cent by using real-time data to improve operational efficiency (IEA 2017). For example, smart thermostats can anticipate the behaviour of occupants (based on past experience) and use real-time weather forecasts to better predict heating and cooling needs. Digital energy services could also allow consumers to become more active participants in the energy system.

In industry, many companies have a long history of using digital technologies to improve safety and increase production. Further cost-effective energy savings can be achieved through advanced process controls, and by coupling smart sensors and data analytics to predict equipment failure. 3D printing, machine learning, and connectivity could have even greater impacts.

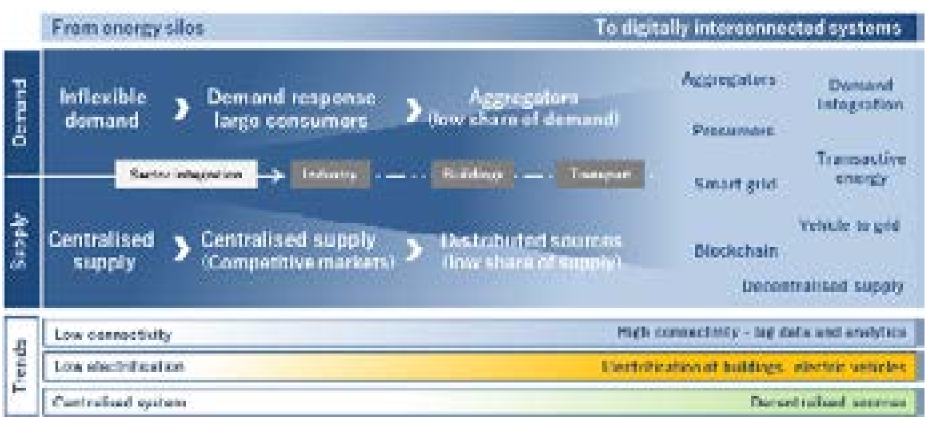
The oil and gas industry has long used digital technologies, notably in upstream, and significant potential remains for digitalization to further enhance operations. Widespread use of digital technologies could decrease production costs between 10 per cent and 20 per cent, including through advanced processing of seismic data, the use of sensors, and enhanced reservoir modelling (IEA 2017).

In the coal industry, digital technologies are increasingly being used in geological modelling, process optimisation, automation, predictive maintenance, and to improve worker health and safety. However, the overall impact of digitalization may be more modest than in other sectors.

In the power sector, digitalization has the potential to save around US$ 80 billion per year, or about 5 per cent of total annual power generation costs (IEA 2017). Digital technologies can help to reduce operation and maintenance costs, improve power plant and network efficiency, reduce unplanned outages and downtime, and extend the operational lifetime of assets.

Digitalization could fundamentally transform the energy system by breaking down boundaries between energy sectors, increasing flexibility, and enabling integration across systems. The electricity sector is at the heart of this transformation, where digitalization is blurring the distinction between generation and consumption (Figure). Digitalization enables four interrelated opportunities: (1) smart demand response and increased system flexibility; (2) greater integration of variable renewables; (3) smart charging of EVs to provide further grid flexibility; and (4) better coordination of distributed energy resources (e.g., rooftop solar PV panels and storage) (IEA 2017).

Figure 2. Possible steps in the digital transformation of the electricity system. The deployment of digital technologies is creating a more interconnected and responsive electricity system, with the potential to help increase flexibility, efficiency and reliability.



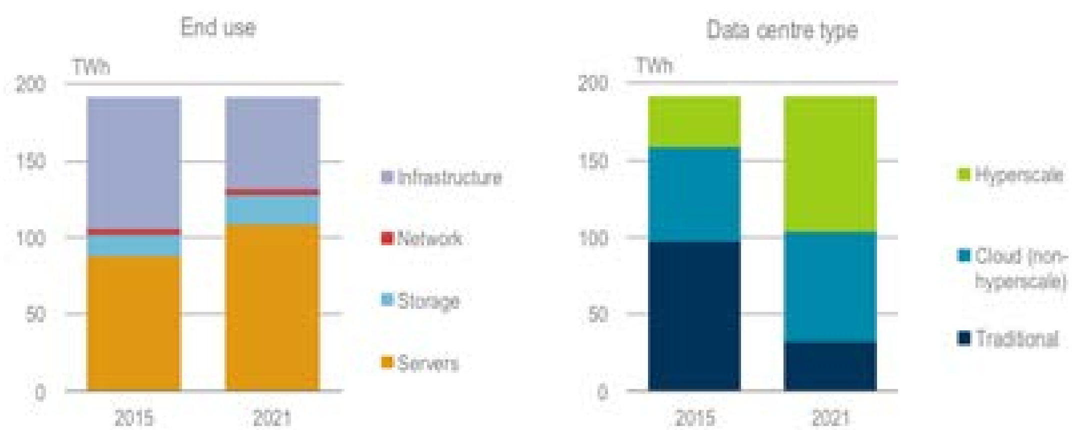
Source: IEA (2017).

Challenges

As the world becomes increasingly digitalized, data centers and data transmission networks are emerging as an important source of energy demand (Figure 3). Global data center electricity demand in 2015 amounted to an estimated 191 TWh, or about 1 per cent of global final demand for electricity (IEA 2019). Despite a projected tripling of data center IP traffic and workloads, global data center energy demand is projected to remain flat to 2021, thanks to continued efficiency improvements and a shift to much greater shares of highly efficient cloud and hyperscale data centers. Data networks consumed around 185 TWh globally in 2015, or another 1 per cent of total electricity demand, with mobile networks accounting for around two-thirds of the total.

Given the rapid pace of technological progress and change, providing credible forecasts of data center and network electricity use beyond the next five years is extremely challenging. While demand for these ICT services are expected to continue to grow strongly, how this affects electricity demand will continue to be largely determined by the pace of energy efficiency gains, which will be influenced by government policy.

Figure 3. Global data center electricity demand by end use and data center type.



Source: IEA (2019).

While digitalization can bring many positive benefits, it can also make energy systems more vulnerable to cyber-attacks. Cyber-attacks are becoming easier and cheaper to organise, and the growth of the Internet of Things (IoT) is increasing the potential "cyber-attack surface" in energy systems. Privacy and data ownership are also major concerns for consumers, especially as more detailed data are collected from a growing number of connected devices and appliances. At the same time, aggregated and anonymised individual energy use data can improve understanding of energy systems, such as load profiles, and help lower costs for individual consumers.

All energy sector stakeholders have a role to play in enhancing the digital resilience and security of an increasingly connected energy system. With solutions and processes producing and using vast volumes of data, questions remain around how best to balance the risks and opportunities of data-driven solutions. Digitalizing traditional energy infrastructure will require careful management, given the inherent limits to interoperability.

Implications on the achievement of SDG 7, other SDGs, and the Paris Climate Agreement

The world requires universal access to modern energy services together with a decisive drop in CO_2 and other greenhouse gas emissions. Almost a billion people do not have access to electricity and some 3 billion to clean cooking (IEA 2018). This leads to about 4 million premature deaths, especially women and children who spend most time indoors (WHO 2014). Universal access is essential for development and environmental sustainability. Positive effects on reduction of greenhouse emissions are likely due to better combustion and shift toward renewables, but are far from sufficient at current rates of progress. The rapid diffusion of mobile phones in the developing world could unlock new business models to provide electricity services to the 990 million people without electricity access today (IEA 2018). Digital technologies can also enable the integration of greater shares of renewables and facilitate harnessing energy efficiency opportunities (see above), supporting the achievement of SDG 7. New digital tools can promote sustainability, including satellites to verify greenhouse gas emissions and technologies to track air pollution at the neighbourhood level.

Policy implications and Recommendations

- **Energy efficiency, increasing the share of renewable energy and carbon capture and storage all play a key role in decarbonizing the energy system while providing access to modern energy for all.** Achieving the Paris Agreement is still possible but only if combined with focus on a broader set of SDGs. Constraints set by the SDGs require a rapid phase-out of fossil-based power generation: more than 70 per cent of electricity will likely need to be produced with zero and low-carbon technologies in 2030 and about 100 per cent in 2050 (TWI2050 2018). This can only be achieved together with a rapid increase in energy efficiency. At the same time, carbon dioxide-removal strategies need to be implemented.
- **Science, technology and innovations (STI) are a powerful driver but the direction of change needs to support sustainable development.** The digital revolution symbolizes the convergence of many innovative technologies, many of which are currently ambivalent in their contribution to sustainable development, simultaneously supporting and threatening the ability to achieve the SDGs. There is an urgent need to bring the sustainability and the digital and technology communities together to align the direction of change with the 2030 Agenda and a sustainable future beyond. There is also a need to implement forward-looking roadmaps and governance structures that allow the mitigation of potential trade-offs of a STI revolution, particularly relating to its impact on the workplace, social cohesion, and human dignity.
- **All energy sector stakeholders have a role to play in managing emerging risks and enhancing the digital resilience of an increasingly connected energy system**. With solutions and processes producing and using vast volumes of data, questions remain around which data will be critical and prioritised, who should own it, and how best to balance the risks and opportunities of data-driven solutions. Digitalizing traditional energy infrastructure will require careful management, given the inherent limits to interoperability found in digital business models.
- **There are a number of actions that policy makers can take to maximise the potential benefits that digitalisation can bring to the global energy system.** Foremost amongst these is policy makers building their own skills and knowledge of digital technologies, so that policy responses can be developed from a more informed position. Improved access to data will also open opportunities to realise the benefits from digitalisation, with governments well placed to develop frameworks and structures to access robust, verifiable, and secure access to data. Improved data access will also improve the ability of policy makers to understand the impact that digitalisation is having on energy demand, because at present forecasting and understanding these impacts remains a challenge.
- **Policies are crucial in shaping a more secure, more sustainable, and smarter energy future.** Several recommendations are not unique to energy, such as related to digital skills or data availability, privacy and security. Others are more specific, such as monitoring the impact of digitalization on energy demand, broadening the discussion on digitalization beyond the energy sector as sectors become more intertwined, designing flexible policies which can accommodate for new technologies and pilot them together with novel technologies to learn from case studies.

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